

3/pv

1 SPARK PLUG FOR AN INTERNAL COMBUSTION ENGINE, AND METHOD,  
2 FOR PRODUCING A SPARK PLUG

3  
4 Related Art

5  
6 The invention concerns a spark plug for an internal combustion engine,  
7 comprising a shell, an insulator located in the shell and composed of a sintered  
8 ceramic material, as well as a center electrode heat-fused into an insulator, and a  
9 terminal stud that have an electrically conductive connection with each other and  
10 are located in the insulator. The invention further concerns a method for  
11 producing a spark plug.

12  
13 Due to the different thermal expansions of platinum and ceramic material, spark  
14 plugs comprising a platinum center electrode heat-fused into an insulator have a  
15 slight gap between the ceramic and the center electrode that allows air or  
16 combustion gases to penetrate. For this reason, the components in the interior of  
17 the spark plug must be stable in the presence of these gases. It is therefore  
18 impossible, for example, to install a carbon-based burn-off resistor in the anterior  
19 region of the spark plug on the combustion chamber side, because the carbon  
20 would be oxidized at the high temperatures by the penetrating atmospheric  
21 oxygen. Additionally, contact pins must be made of materials that are stable in  
22 the presence of the penetrating gases. Contact pins having high thermal  
23 conductivity, e.g., those made of copper, can therefore not be used.

24  
25 A spark plug is made known in WO 97/49153, about which it is proposed that the  
26 contact pin be replaced with an electrically conductive ceramic-metal mixture in  
27 order to prevent mechanical stresses, because the coefficients of thermal  
28 expansion would then be the same.

29  
30 The object of the invention is to further develop a spark plug of the type  
31 described initially such that a gas-tight, reliable seal is ensured that can be

1 produced cost-effectively. The object of the invention is further to create a  
2 method for producing such a spark plug.

### 4 Advantages of the Invention

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6 With the spark plug having the features in Claim 1, the insulator and the cermet  
7 have the same or similar material properties, which ensures sealing. The fact that  
8 the material properties are the same yields advantages for production as well as  
9 operation: insulator and cermet can be easily sintered together, because they  
10 have the same shrinkage behavior. Since insulator and cermet also have the  
11 same thermal expansion, no gaps are produced as a result of different thermal  
12 expansions. As a result of the good seal that is achieved, materials can be used  
13 in the anterior region of the spark plug that are not sufficiently stable in the  
14 presence of air or combustion gases at the high temperatures occurring during  
15 operation, e.g., resistors having carbon as the conductive phase or contact pins  
16 made of copper and having good thermal conductivity. Only a relatively small  
17 quantity of metal is needed for the metallic phase of the cermet, which results in  
18 low costs for the spark plug.

19  
20 According to a preferred exemplary embodiment of the invention, it is provided  
21 that the ceramic phase of the cermet is composed of  $\text{Al}_2\text{O}_3$ , and the metallic  
22 phase is composed of platinum or a platinum alloy. This cermet can be easily  
23 sintered together with the insulator, because it comprises the same sintering  
24 properties as the insulator.

25  
26 According to a preferred exemplary embodiment of the invention, it is provided  
27 that a ceramic granulated material is used to produce the cermet, the granules of  
28 which are provided with a surface coating of a material having good electrical  
29 conductivity. Due to the difference in size between the granules of the granulated  
30 material—which preferably have a diameter in the range between 90  $\mu\text{m}$  and 150  
31  $\mu\text{m}$ —and the pulverized material—the particles of which are less than 10  $\mu\text{m}$  in

size, a ceramic micro-structure results after sintering having a network of thin metal tracks, e.g., made of platinum, that ensures sufficient electrical conductivity despite the small quantity of metal used. It is sufficient, for instance, for the metallic phase of the cermet to constitute a quantity between 10 and 15 % by volume. The precious metal that is preferably used is therefore used sparingly.

Reference is made to the explanations hereinabove with regard for the advantages achieved with the method according to the invention.

According to a preferred exemplary embodiment of the method, it is provided that the granules of the ceramic granulated material are coated with the material having good electrical conductivity by stirring in a diluted suspension. In this fashion, the granules can be coated with the electrically conductive material, e.g., platinum, in cost-effective fashion, so that the electrically conductive network is produced in the interior of the cermet after the granulated material is sintered. As an alternative, the material having good electrical conductivity can also be applied to the granules of the granulated material using an organic binding agent, for instance, or it can be applied via vapour deposition or sputtering.

#### Brief Description of the Drawing

The invention is described below using a preferred exemplary embodiment shown in the attached drawings.

- Figure 1 shows a partial sectional view of a spark plug according to the invention;
- Figure 2 shows an enlarged view of a section in Figure 1;
- Figure 3 shows an enlarged micrograph of a part of the insulator of the spark plug according to the invention with center electrode heat-fused into an insulator;
- Figure 4 shows an enlarged section of the micrograph in Figure 3.

## Detailed Description of the Exemplary Embodiment

A spark plug 10 is shown in Figure 1 that comprises a shell 12 composed of metal and having threads 14, by means of which the spark plug can be screwed into a bore in a cylinder head of an internal combustion engine. An insulator 16 is housed in the interior of the shell 12, which is composed of a sintered ceramic material such as  $\text{Al}_2\text{O}_3$ . A center electrode 18 and a terminal stud 22 that have an electrically conductive connection with each other are housed in the interior of the insulator. A spark can therefore be produced in known fashion between the center electrode 18 and ground electrodes 26 attached to the shell 12 by applying a voltage potential between a terminal nut 24 screwed onto the terminal stud 22 and the shell 12.

The seal and the electrically conductive connection between terminal stud 22 and center electrode 18 is designed as follows: a cermet 28 abuts the center electrode 18, which is followed by a burn-off resistor 30 (with a contact set between them, if necessary), followed by a contact set 32 that is penetrated by the terminal stud 22.

The gas-tight seal is described below in detail using Figures 2 through 4.

The insulator 16 comprises an offset bore in its interior, the anterior end 36 of which houses the center electrode. The center electrode—which is preferably composed of fine grain-stabilized platinum or a fine grain-stabilized platinum alloy—comprises a nail head 38 that rests on the shoulder toward the greater bore diameter. The center electrode is heat-fused into the insulator and is sealed over the nail head by the cermet 28 and additionally fixed in position. The cermet 28 is composed of ceramic material and a metallic phase. The same material is used for the ceramic phase as for the insulator, i.e.,  $\text{Al}_2\text{O}_3$  having the known additives of sintering auxiliary agents, such as  $\text{SiO}_2$ ,  $\text{CaO}$ ,  $\text{MgO}$ , etc. Platinum or a platinum alloy is used for the metallic phase.

1 The cermet is produced starting with a granulated material of the insulator  
2 material having a granule size between 90  $\mu\text{m}$  and 150  $\mu\text{m}$ . The granules of the  
3 ceramic granulated material are then coated with the platinum or platinum alloy  
4 serving as electrical conductor, e.g., by stirring in a mixer with a diluted platinum  
5 suspension, and then drying. The platinum or the platinum alloy is present in the  
6 suspension in powder form; the individual granules are less than 10  $\mu\text{m}$  in size.  
7 In this fashion, granules are obtained that are coated with a small quantity of  
8 platinum or the platinum alloy. In order to achieve the electrical conductivity  
9 needed later on, it has proven sufficient if the quantity of platinum or platinum  
10 alloy constitutes 10 to 15 % by volume of the cermet.

11  
12 The ceramic granulated material coated in this fashion is filled into the  
13 insulator—which was produced using a usual method and may have been pre-  
14 annealed at a temperature of 1000° C to increase hardness—so that it lies above  
15 the nail head 38 of the center electrode 18 inserted in the location hole 38. The  
16 granulated material is then compressed using a stamp using a force of  
17 approximately 100 to 150 N. Finally, the insulator is sintered together with the  
18 granulated material at approximately 1600° C, in the usual fashion. This results in  
19 a very good bond between the insulator and the cermet, because the same  
20 material is used as the basic material for the cermet as for the insulator, and  
21 good electrical conductivity of the cermet is produced due to the platinum or the  
22 platinum alloy, because a network of thin tracks of platinum or the platinum alloy  
23 is produced during sintering. This is shown in the micrographs in Figures 3 and 4.  
24 A nearly uniform micro-structure of insulator 16 and cermet 28 is produced,  
25 which differs only in terms of the platinum or platinum-alloy tracks present in the  
26 cermet 28.

27  
28 Since the same material is used for the ceramic phase of the cermet as for the  
29 insulator, a particularly good seal is produced on the back side of the center  
30 electrode 18. This seal is also maintained over long service lifes, because the  
31 cermet and the insulator have the same thermal expansion, so no thermal

1 stresses and cracks or gaps resulting therefrom can occur. Carbon can therefore  
2 be used, for example, as electrically conductive material for the burn-off resistor  
3 30, even though this material is not sufficiently stable in the presence of air or  
4 combustion gases at the operating temperatures; the seal is so reliable that the  
5 carbon does not come in contact with the air or the combustion gases.

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